NATIONAL BUREAU OF STANDARDS REPORT

6337

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OF
THREE 200-WATT SERIES-SERIES TRANSFORMERS
WITH MULTIPLE LAMPS AS LOAD

By
James E. Davis

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
0201-20-2327	March 1959	6337

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Prepared for
Ship Installations Division
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Department of the Navy
Washington 25, D. C.
Project No. TED NBS SI-5003

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OUTPUT CHARACTERISTICS OF THREE 200-WATT SERIES-SERIES TRANSFORMERS WITH MULTIPLE LAMPS AS LOAD

This report presents the data from tests made of series-series transformers using different wattage, 120-volt, multiple-type lamps as the load. Three 6.6/6.6-ampere, 200-watt, runway-lighting transformers, each from a different manufacturer, were tested to determine output characteristics. The characteristics of the transformers are shown as plots of secondary voltage versus current and of output wattage as a function of the rated wattage of the lamp load. Plots of the computed light output of the lamps as a function of rated lamp load are also included.

1. INTRODUCTION

The purpose of the tests was to determine the light output that can be obtained from multiple-type lamps when these lamps are used as the load for series-series transformers. Several auxiliary visual aids requiring lighting have been or need to be developed for use near the runways of airfields. These include illuminated runway-distance markers, taxiway-turnoff indicators, marker lights for arresting gear or barriers, special obstruction lighting, etc. Frequently these aids are located where they can be conveniently connected into the runway-lighting circuits. The cost of installing these auxiliary aids can be reduced if existing circuits and standard equipment can be utilized, thus eliminating the necessity of installing additional circuits or of developing new equipment. Series-type lamps operated in the conventional manner from the runway-lighting circuits are often unsatisfactory for use in the light sources of these auxiliary aids because the change of intensity with changes in current setting of the regulator is too great. The use of saturated-core transformers has often been considered for this purpose. Since rubber-covered series-multiple transformers are not available, the use of lamp loads which will cause the series-series transformers to be saturated at all regulator output currents has been suggested as a means of reducing the change in intensity.[1,2,3] The lamps which are usually considered for such use are multiple-type lamps with rated voltage in the range 60 to 120 volts.

In the design of special lighting units using series-series transformers with multiple-type lamps, two important factors should be considered in selecting the lamp type: first, the intensity that will be obtained, and second, the change in intensity for the different intensity settings of the regulator. Because these transformers were not designed for use with multiple-type lamps, data for determining the light output that can be obtained were needed. The most reliable data will be obtained from measurements of the output of a series-series transformer with multiple-lamp loads when this transformer is part of a runway-lighting circuit similar to that which will be used on airfields. The output of the transformers and the resulting light output of the lamps will be affected by the following parameters: the rated voltage of the lamps, the rated wattage of the lamps, the rating of the transformer, the design or construction of the transformer, the circuit into which the transformer is connected, the load of the regulator, and the type of regulator from which the power is obtained. The parameters which were investigated in this report were: 1) variation of the wattage of 120-volt lamps; 2) transformers of the same type, produced by three different manufacturers; and 3) two load conditions of the regulator.

2. TEST PROCEDURE

The tests were made by connecting the transformer with its load into an airfield runway-lighting circuit supplied by a constant-current regulator. The output voltage and current of the transformers were measured for each test condition. The values of voltage and current were corrected for all significant losses in the measuring instruments.

Three 200-watt, 6.6/6.6-ampere, 5000-volt, rubber-covered, series-series, isolating transformers were tested. Each transformer was produced by a different manufacturer but all had been made to meet the requirements of Air Force Specification 32635. The manufacturers were American Gas Accumulator Company, Jefferson Electric Company, and Line Material Company. These transformers were stock items obtained from a Naval Supply depot. The characteristics of each transformer were determined when 120-volt lamps were used as the load. Three 25-watt, two 100-watt, and three 300-watt lamps were used in combinations to obtain 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 400, 500, 600, 700, 800, 900, and 1000 rated watts as the load. Each transformer was tested individually. The power for the tests was supplied by a type NC-3, 15-kilowatt, 2400-volt-input, 6.6-ampere-output runway-lighting regulator connected to a 2400-volt-distribution system without

special voltage regulation. Two load conditions of the regulator were used in testing each transformer:

1. The test transformer with its load was connected into a runway-lighting circuit of thirty-four 200-watt, series-series transformers and their lamps and three 200-watt transformers with burned-out lamps across their secondaries. The circuit consisted of approximately 16,000 feet of No. 12, 3000-volt cable in metallic duct. The output voltage and current readings of the regulator when it was connected to the runway-lighting circuit only were as follows:

Step 1	440 volts	2.82 amperes	1.24 kva
Step 2	550 volts	3.40 amperes	1.87 kva
Step 3	670 volts	4.10 amperes	2.74 kva
Step 4	1000 volts	5.12 amperes	5.12 kva
Step 5	1440 volts	6.50 amperes	9.36 kva

For this condition, measurements were made at each intensity step.

2. The load on the regulator was the test transformer with its load. For this condition, measurements were made at intensity steps 1, 3, and 5 only.

3. DISCUSSION OF RESULTS

The output voltage-current characteristics of the test transformers as functions of the load are shown in figures 1, 2, and 3. The solid-line curves were plotted from data obtained when the test transformer was connected into the runway-lighting circuit. The values for the broken-line curves were obtained when the test transformer only was connected to the regulator. Figure 4 indicates the output power versus the rated wattage of the connected load of each of the transformers when the transformer was tested in the runway-lighting circuit.

When the load on the transformer was small, the changes of the output voltage-current characteristics were complex. As the rated wattage was increased above 150 watts, the output characteristics were approximately linear until the transformer neared magnetic saturation. Although the curves of output voltage-current and of power were similar in shape for the different transformers, the values for a specific load and intensity setting differed appreciably. Note that at the larger transformer loads the output power exceeded the rating of the transformer.

Considerable differences in the output characteristics of the transformers were obtained as the load on the regulator was changed from about 10 kilowatts to approximately no load. These differences were probably the result of change in waveform in the output of the regulator.

Figures 5, 6, and 7 indicate the light output in lumens of the multiple lamps as a function of the rated wattage of the load of each transformer when the transformer was connected into the runway-lighting circuit. The values of light output were obtained by multiplying the rated lumen output of the lamps by an applied-voltage factor. The rated lumen values used were 265 lumens for 25-watt lamps, 1630 lumens for 100-watt lamps, and 5900 lumens for 300-watt lamps. These values were obtained from General Electric Company's Large Lamp Catalog.[4/] The applied-voltage factors were obtained from National Bureau of Standards Report 6190, figure 20b, for a 500T20, 120-volt lamp.[5/] The peak light output for any intensity setting of the regulator occurred when the rated wattage of the lamp load was between 200 and 500 watts. The maximum light output of the lamps when connected to the different transformers ranged from 1000 to 2100 lumens. At intensity steps 5 and 1 for a given load, the minimum ratio of light output was about 2 to 1 for loads over 100 watts; whereas the ratio of light output is 500 to 1 for a 200-watt, 6.6-ampere, series-type lamp.

A change of illumination of 5 or 10 to 1 was determined to be the most suitable for externally-illuminated runway-distance markers.[1/] This ratio, as well as other ratios of light output for intensity steps 5 and 1, can be obtained by selecting lamps of loads of proper rated wattages. Although a study of the effects of using lamps of a different voltage, 60 or 75 volts for example, was not included in this study, lamps of these voltages may be useful in some applications. The 75-volt lamps will generally operate at a higher efficiency than will the 120-volt lamps.

4. CONCLUSIONS

The data obtained from these tests will be helpful in selecting the multiple-type lamps to be used as the load of series-series transformers for illuminating special visual aids. The maximum light output obtained ranged from 1000 to 2100 lumens, depending on the make of the transformer.

The change in light output produced by changing the intensity setting of the regulator can be greatly reduced by using multiple-type lamps as the load of series-series transformers. Many desirable intensities and variations in light output may be obtained from series airfield-lighting circuits and standard equipment if multiple-type lamps of suitable voltage and wattage ratings are selected for use.

5. RECOMMENDATIONS

To determine the effects of the other parameters additional tests are needed.

March 1959
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2. C. A. Douglas, I. Nimeroff, A. N. Hill, NBS Report 4741, Development of Optimum Runway Lights for Jet Aircraft, Interim Report No. 1 (1956)

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4. Large Lamp Catalog IE-301, p. 23, General Electric Company

5. NBS Report 6190, Current-Intensity, Voltage-Intensity, and Current-Voltage Characteristics of Airfield Lighting Equipment (1958)

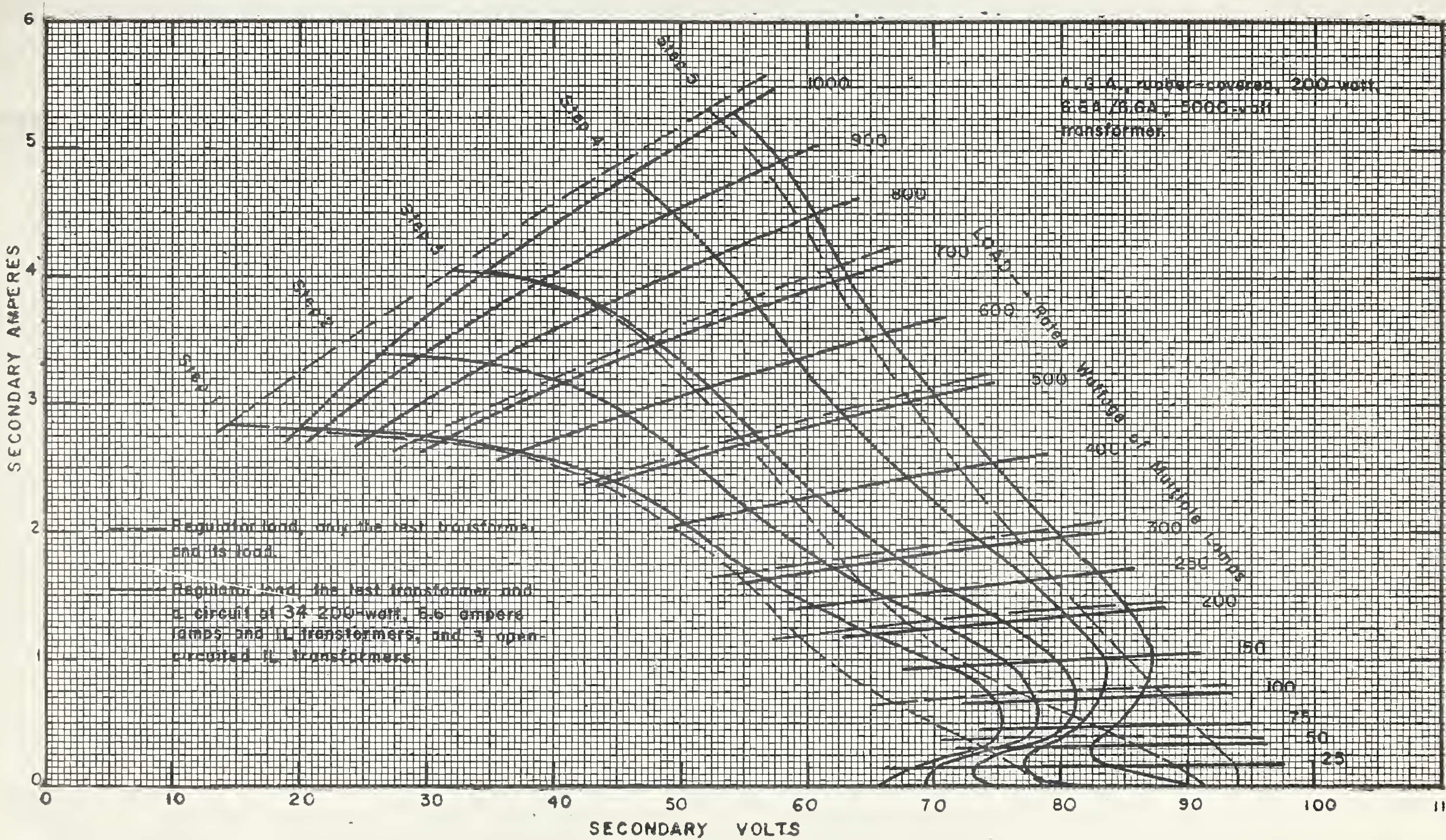

Figure I. OUTPUT CHARACTERISTICS OF SERIES TRANSFORMERS (with Multiple-Lamp Loads).

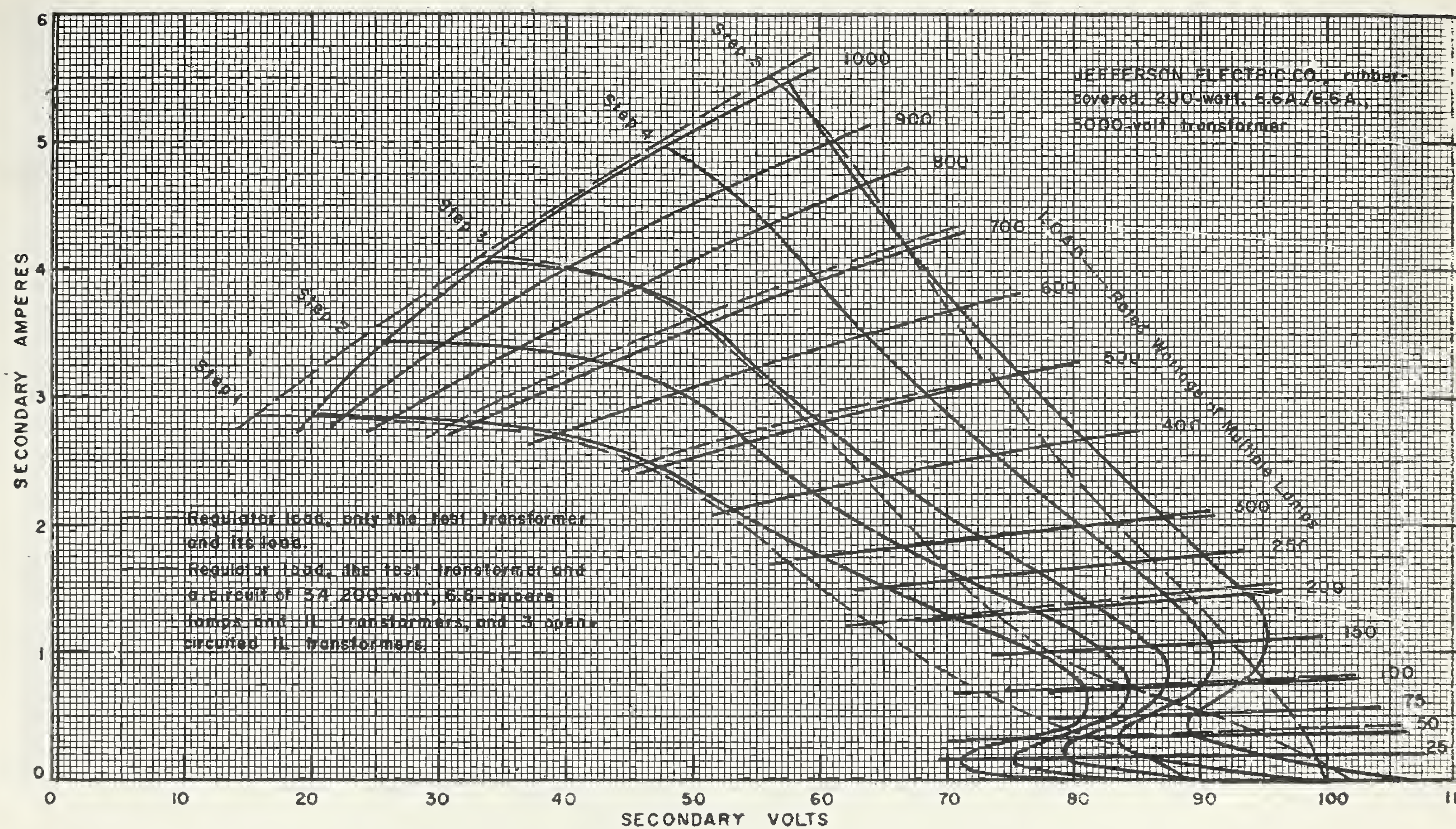

Figure 2. OUTPUT CHARACTERISTICS OF SERIES TRANSFORMERS (with Multiple—Lamp Loads).

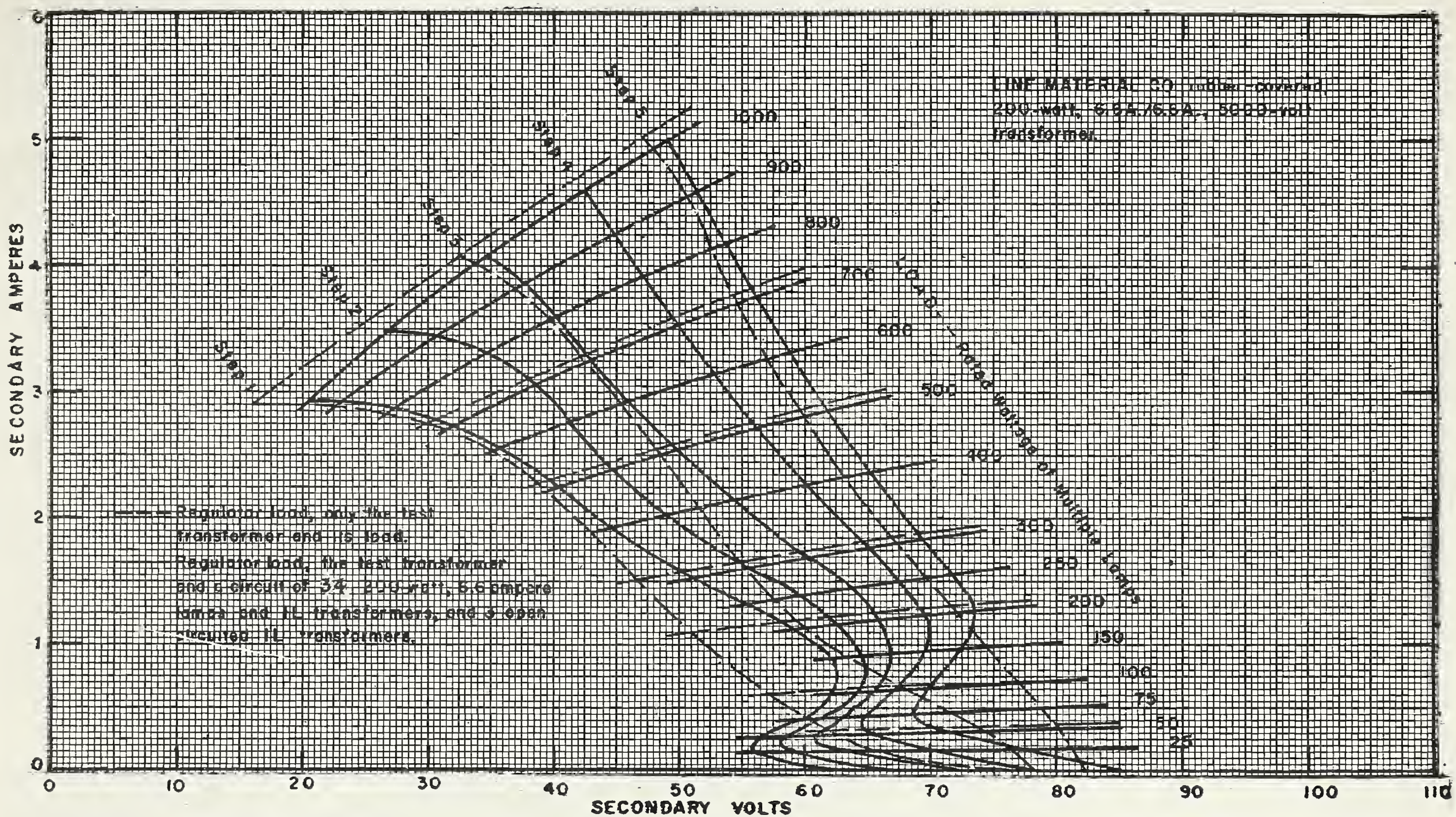

Figure 3. OUTPUT CHARACTERISTICS OF SERIES TRANSFORMERS (with Multiple—Lamp Loads)

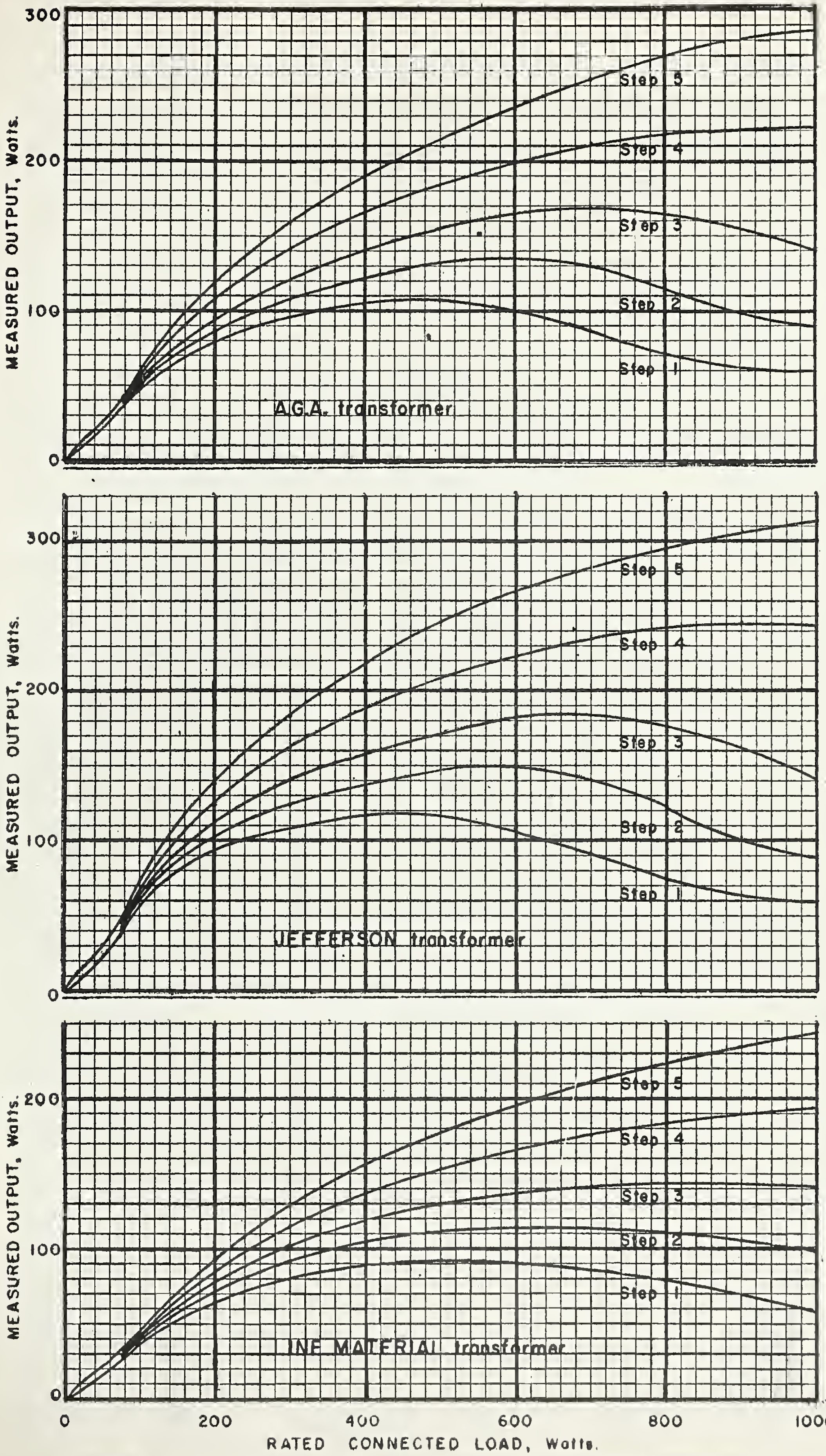

Figure 4. Output power of series transformers with multiple-lamp loads.

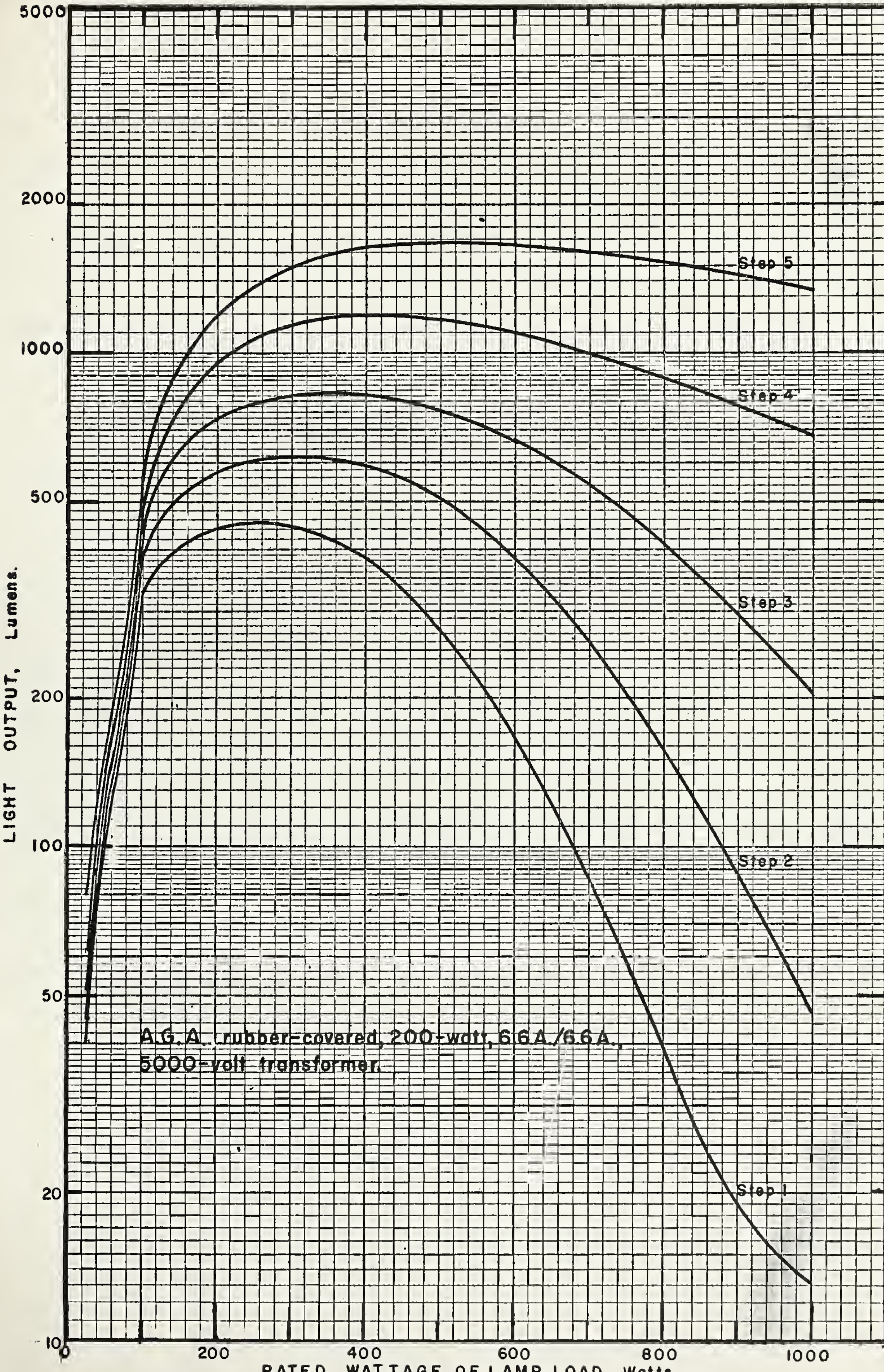

Figure 5. Lumen output of multiple-lamp loads for a series transformer.

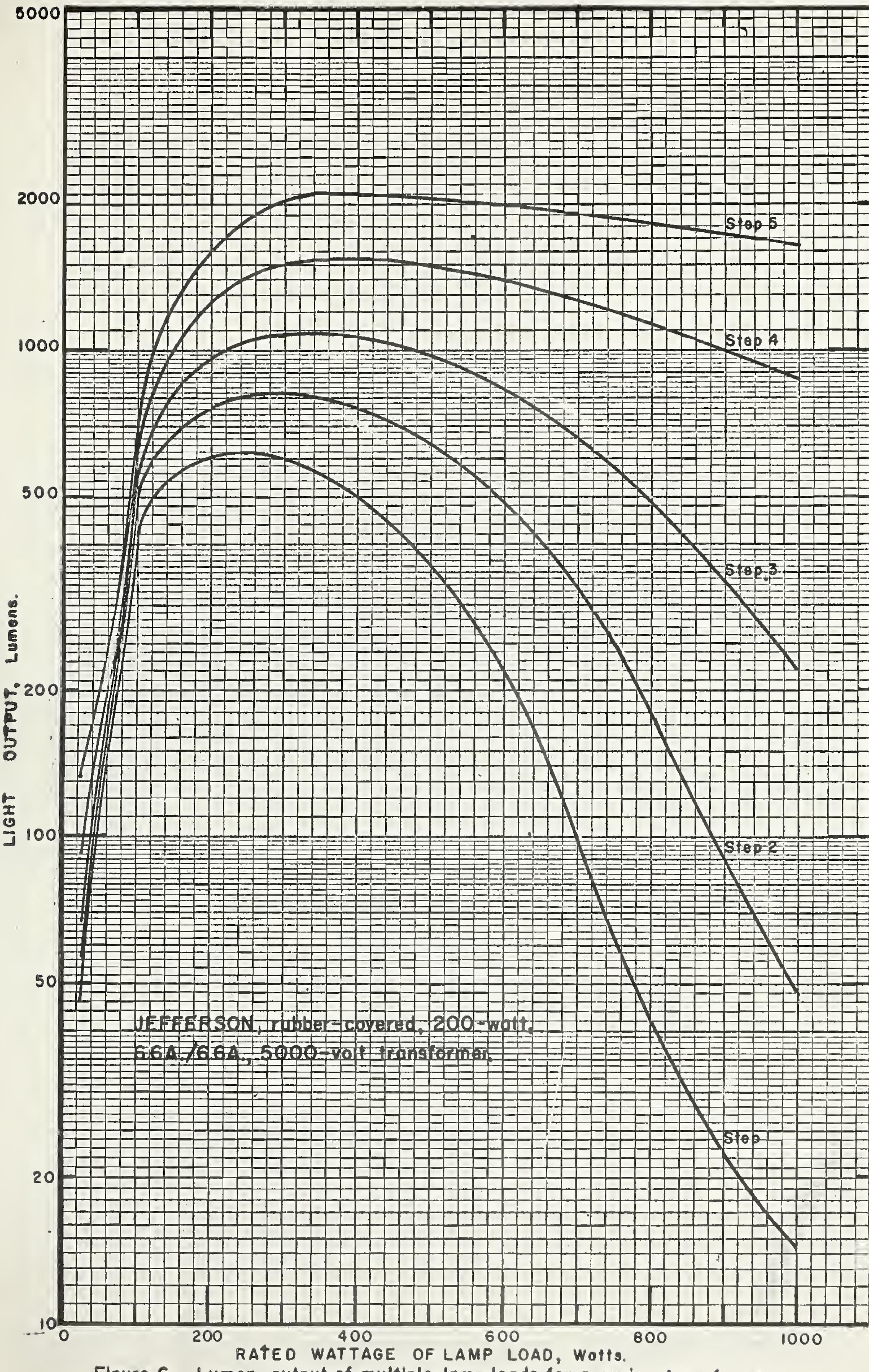

Figure 6. Lumen output of multiple-lamp loads for a series transformer.

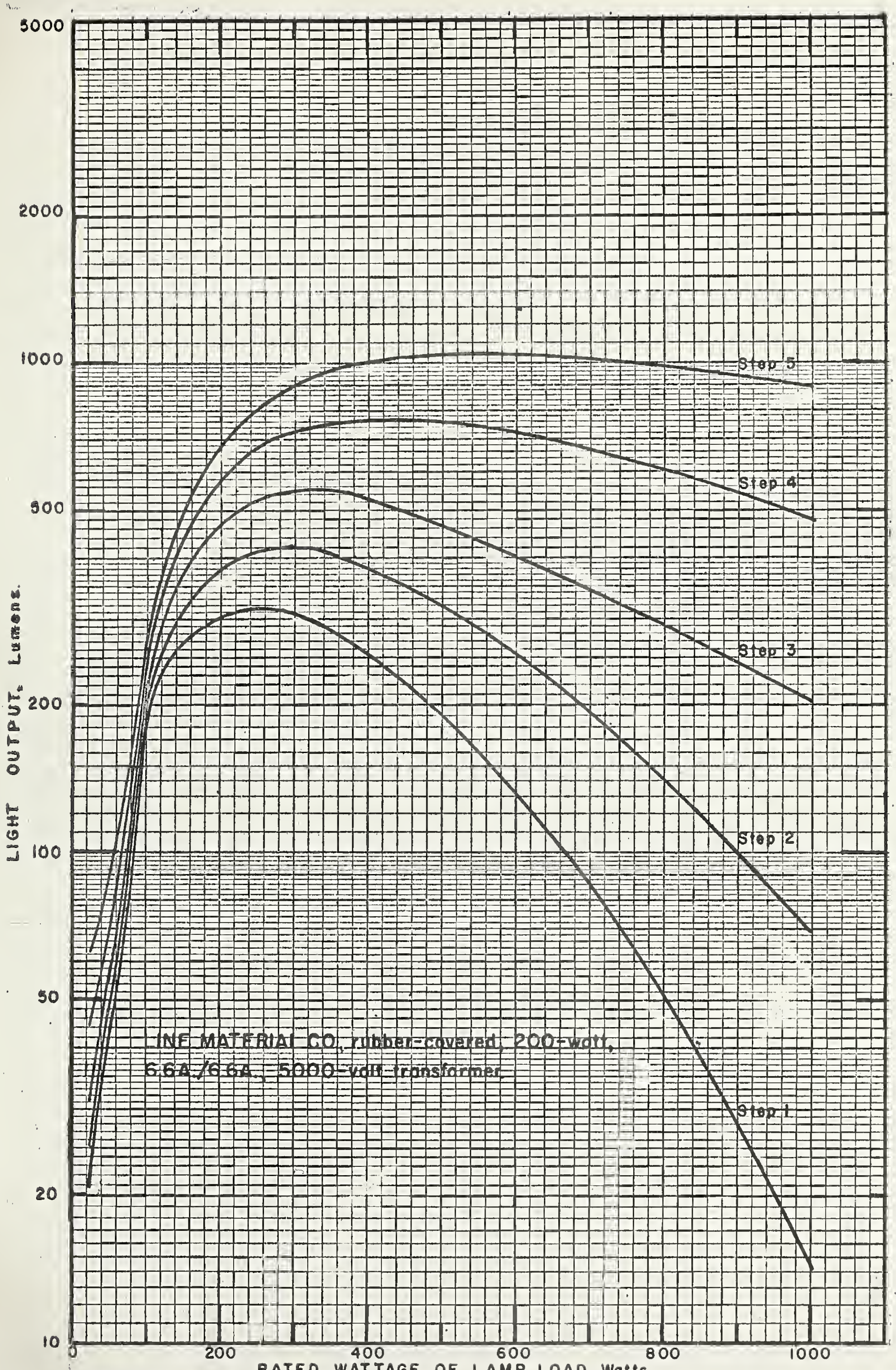

Figure 7. Lumen output of multiple-lamp loads for a series transformer.

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